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THE AMERICAN NATURALIST

VOL. XXXI.

February, 1897.

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NOCTURNAL PROTECTIVE COLORATION OF MAM- MALS, BIRDS, FISHES, INSECTS, ETC.

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Although much has been written regarding the protective and imitative colors and forms of various animals, as seen by daylight, very little attention has been paid to their protective colors as seen by moonlight, twilight, and starlight, when large numbers of species of small mammals and fishes, and numerous insects are most active in search of food and most of the large carnivorous and insectivorous species are abroad in search of their prey. Moreover most birds and many fishes and insects sleep in exposed situations and are thus subject to the attacks of nocturnal predaceous species. The latter, in turn, need protective colors for the night-time, in order to avoid the notice of their prey. One of the most evident effects of moonlight or starlight is to give very black shadows. In the case of bright moonlight these black shadows of trees, etc., may be broken up by patches of white moonlight. Therefore, black or dark-brown animals are nearly invisible in such shadows. If black animals have patches of white or light yellow these will serve a useful purpose by breaking up and obscuring the outlines of bird or beast and look like patches of moonlight on a shadow.

¹ (Abstract of a paper read before the Morphological Society. Dec. 30, 1896.)

Accordingly we find many nocturnal carnivorous mammals that are black (*e. g.*, minks, fisher, bears) and some that are black and white. We also find numerous black, as well as black and white, birds, insects, etc., whose colors can best be explained as due to the influence of natural selection among protective nocturnal colors. The dark gray and brownish-gray colors so common among small nocturnal mammals, like mice, arvicolæ, moles, shrews, marsupials, etc., are highly protective at night. Even when these creatures are running about among green grass and weeds they are scarcely visible in a feeble light. Such colors are not at all protective in the day time, in such places. Moreover, such mammals usually hide in holes or crevices in the day time, where the color does not matter.

Most nocturnal black, brown, and dark gray insects, like the ground beetles, crickets, ants, etc., unquestionably find protection in these colors, though they are conspicuous in the day time. Among diurnal birds and insects there are, also, many cases of conspicuous and bright colors that become protective by moonlight and starlight, when these creatures are asleep or quietly resting among foliage or flowers, and most exposed to their nocturnal enemies. In general, it may be said that in all cases where black or very dark colors are strongly contrasted with white, yellow, or other light markings, these patterns are more likely to be protective at night than in the day time. Such colors may be due, in many cases, to other causes, but when no special cause for their origin can be found, they are probably due, in most cases, to nocturnal protective value, and this can be definitely ascertained by a study of the nocturnal habits and surroundings.

Many of our native butterflies have bright and conspicuous colors which are the reverse of protective in the daytime, when their acute senses and active habits afford fair protection. But I have observed that at night, when roosting on flowers, their colors so blend with those of the flowers as to render them inconspicuous, even in good moonlight. Many species of *Argynnis* and allied genera are conspicuously marked with red, brown, and orange on the under side of the wings, and have bright silvery spots or blotches in addition, so that they are

conspicuous in the daytime. I have noticed that when these large butterflies are roosting at night on goldenrods and other favorite flowers, with their wings folded up over the back, their colors not only blend with those of the flowers but their silvery spots shine in the moonlight like the dewdrops that surround them.

Many birds, insects, etc., have acquired colors that are equally protective both by day and by night. This is true in the case of the green colors of those that live on or amongst foliage, and in the case of those that have dull gray and brown colors, imitative of the bark of trees on which they rest. It also applies to bright colored insects that live on flowers of the same colors. But the multitudes of cases, which cannot be explained in this way, are probably due to special nocturnal protection.

Many fishes that rest at night amongst the stems of aquatic grasses, sea-weeds, etc., have dark or black stripes crossing the body transversely, obliquely, or longitudinally. Such colors are highly protective at night, when they are most exposed to their predaceous enemies, for the dark bands then resemble the dark stems and shadows of the weeds, and serve admirably to conceal the outline of the fish. Black fins and tails serve a similar purpose. Such markings of fishes are generally more distinctly developed at night than in the day time, as explained in the next article.

In a similar way, the striped colors of the tiger are doubtless more effective for concealment at night, or in the dusk of evening, among the stalks of reeds and shrubs, than in the day time. The same is true of the colors of the spotted jaguar, leopard, etc.

The common raccoon is fairly well protected even in the day time by its gray fur, when resting on the large gray branches of trees; but as it generally hides by day in holes, we must regard its peculiar coloration as due to nocturnal protection, for which it is eminently adapted.

Nocturnal and Diurnal changes in the Colors of Certain Fishes, and of the Squid (Loligo), with notes on their Sleeping Habits.—These observations were mostly made in the U. S. Fish Commission Laboratory, at Wood's Holl, Mass., in 1885 to 1887, when the laboratory was in excellent condition for biological studies. In order to observe the nocturnal habits of the fishes, etc., in the aquaria, the gas was turned down low, so as to give a light just sufficient for distinct vision, after every one except myself had retired. Great care was also taken not to jar the floor or furniture. Under these conditions many interesting observations were made. It was noticed that while many species became very active others took this opportunity to sleep, and in doing so, assumed unusual colors and positions. Several species of fishes, while asleep, had colors very different from those seen in the day time. Others showed a decided increase in the intensity or contrast of their colors, without changing the pattern. The latter was the more common habit, and was noticed especially in the case of species that have longitudinal, transverse, or oblique dark bands or stripes or irregular mottlings. As previously explained, these dark stripes are highly protective colors for fishes that rest at night among weeds and grasses. Among those showing this change are several species of minnows (*Fundulus*), and the king-fish (*Menticirrhus nebulosus*), in which the blackish stripes come out more strongly and clearly when asleep than when awake. The black sea-bass, (*Serranus furvus*), especially when young, shows its black markings more clearly when asleep. The sea robins (*Prionotus palmipes* and *P. evolans*), and various species of flounders show more strongly contrasted and darker colors than in the day time. But the scup or porgy (*Stenotomus chrysops*) shows much more remarkable changes in color. This fish, in the day time, usually has a bright silvery color, with a brilliant pearly iridescence, but at night, while asleep, it becomes dull bronzy or gray, and is crossed by about six transverse black bands, colors very effective for concealment among the stalks of eel-grass or sea-weeds. If aroused by suddenly turning up the gas, it immediately resumes its day time colors. If killed in alcohol this fish, and many others, as well as the

squids, usually taken on their nocturnal colors, though these generally soon fade out.

A species of file-fish (*Monacanthus*) which has, in the day time, mottled olive-green and brown colors, with slightly darker fins and tail, when sleeping becomes pallid gray, or nearly white, and the fins and tail become black. This and other related species took curious positions while asleep, often leaning up obliquely, with the back against the glass of the aquaria and the abdomen resting on the bottom; sometimes, also, leaning up in a corner of the aquarium with the body curved, or against stones in similar attitudes.

The tautog or black fish (*Tautoga onitis*) usually sleeps on one side, resting under the edges of rocks, or half buried in sand or gravel, much after the manner of flounders. They often had their bodies variously bent. This fish did not show any marked change of colors, but its ordinary dark colors are nocturnally protective.

The common squid, when resting quietly on the bottom, late at night, and apparently asleep, takes on its darkest colors, due to the full expansion of the brown and purple chromatophores, so that the color is much like that developed when excited in the day time, and similar to the usual color of alcoholic specimens. When swimming quietly in the day time the usual color is pallid or translucent bluish-white, with very small, scattered, dark specks, due to the strongly contracted chromatophores. It takes this color, also, when resting upon the light sandy bottoms, waiting for the approach of the small fishes on which it feeds. It has the power of changing its colors at will, but its nocturnal color is probably automatic and protective.